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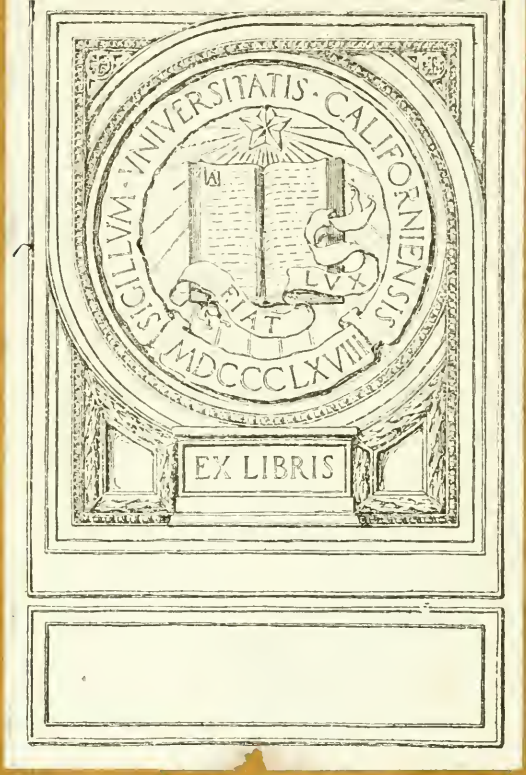
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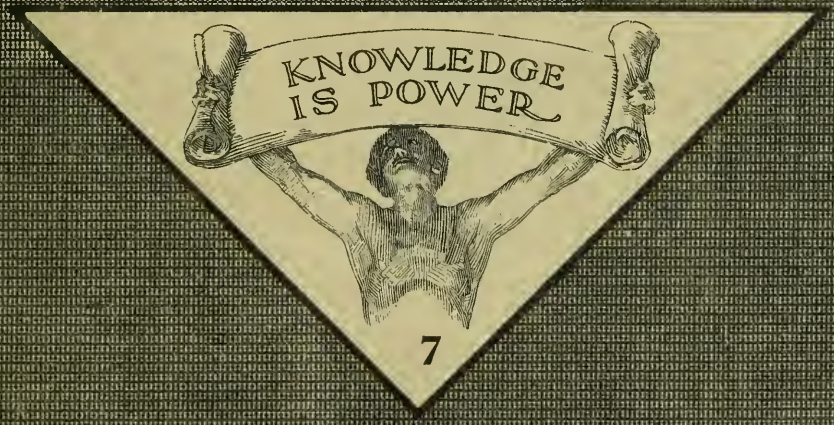
Mechanical Arithmetic

or the

History of the Counting Machine



Washington Institute

Chicago

LECTURES ON BUSINESS

Edited by THOMAS H. RUSSELL, A. M., LL. D.

Mechanical Arithmetic

or

The History of the Counting Machine

by

D. E. FELT

President of
ELT & TARRANT MFG. CO., Chicago
Manufacturers of the Comptometer

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Introduction

This lecture by the well-known inventor and manufacturer of the famous calculating machine known to all American bookkeepers and office men as the Comptometer, will be appreciated by all business men and students of Business who realize the wonderful strides made in the last quarter of a century in the mechanical aids to efficiency in the accounting departments of commercial life.

Mr. D. E. Felt stands high on the roll of successful American inventors, and, unlike so many of them, he possesses a well-developed business instinct that has enabled him to reap the due reward of his inventive genius. His standing as an inventor is recognized in Europe as well as in the United States, and during the visits to the European museums to which he refers in his lecture he was signally honored by being permitted to make close examination and tests of the historic calculating machines preserved in those institutions; so that he speaks with unusual authority on this interesting subject of the development of "Mechanical Arithmetic" from the earliest times of which records exist.

Mr. Felt tells in his lecture his own story of the dawn and origin of his great idea, and how he proceeded to carry it into effect; and this part of his lecture, brief as it is, indicates the magnitude of his undertaking, while leaving to the imagination of the reader the years of effort that were required to give to the world of commerce and finance the splendid mechanical calculator with which his name will ever be associated in the history of American invention and American business.

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After his invention of the Comptometer, it is interesting to note, it took him almost three years to sell the first hundred machines. But these were the first key-operated adding machines to be manufactured and sold in this country. Today they are found in every large office and accounting department in America, effecting large savings in time, effort, and money.

In 1888 Mr. Felt tackled the problem of listing machines, which others had tried, without success, to solve. He finally perfected the Comptograph, which was the first successful listing machine, and an invention of no small importance.

Thus while Mr. Felt's Comptometers were the pioneers of key-driven adding and calculating machines, his Comptographs were the pioneers of keyboard listing adding machines, and both have been of immense service in "leading the bookkeepers out of bondage."

But the tale of the inventor's important contributions to rapid calculation is not yet fully told. In 1901 Mr. Felt, after infinite labor, produced the first **duplex** key-driven calculator, and thus made practicable rapid multiplication by machinery. Since that time public contests at Office Appliance and Business Shows held in Madison Square Garden, New York, and in other cities have demonstrated the marvelous possibilities of Mr. Felt's mechanical calculators and a deep debt of gratitude is due him from the business world.

T. H. R.

Mechanical Arithmetic

or

The History of the Counting Machine

By D. E. FELT
President FELT & TARRANT MFG. CO., Chicago
Manufacturers of the Comptometer

I will endeavor to give you an idea that the adding-machine art is not quite as new as one might think. We are apt to think that adding machines are something very new.

When I say "adding machines" or "computing machines," I mean counting machines, because all mathematics is counting. We are quite apt to consider multiplication or division something different from counting. Primarily it is addition, nothing else; or, to be more exact, it is counting. The reason that we say multiplication, or practise what we call multiplication, is that we have learned the multiplication table. We make a sort of short-cut counting, because we have already learned a few simple elements in counting, like 2×4 are 8, or 3×12 are 36.

The first arithmetic, the first counting, was undoubtedly mechanical. We say "to calculate." The word "calculate" means to count with pebbles. **Calculi** is Latin for pebbles, therefore calculating is counting with pebbles. That is where the term started.

We call the numeral characters which we use digits. "Digits" mean fingers. If men had six fingers instead of five, we would have had the duodecimal system of notation, instead of the decimal, and it would have been very much easier to make arithmetical calculations than it is, using as we do the decimal system of tens. For instance, with the decimal system, if we want to multiply anything by twenty-five, simply divide by four and add two ciphers. We can make a few short cuts with the decimal system like that, but if we used twelve numeral characters or twelve digits,—that is, the duodecimal system,—we could have made a great many short cuts. That is why astronomers use a sort of different mathematics. That is why they divide the circle into three hundred and sixty degrees instead of into one hundred degrees, because twelve can be divided in a great many ways—3, 4, 6, and 2 are all factors of 12. In ten we have only 2 and 5.

There isn't any way to tell just what the earliest calculating machines were. We can only make a surmise. We know that from the earliest historic times people have calculated with pebbles; then they went a little farther, because the pebbles lying on the ground or on the boards would get mixed up, and instead of using pebbles they used beads, strung on rods, and by putting a number of rods in a frame made and used the device called "abacus."

There were different systems of those rods. There is a system, used largely in China and the far East, which has five beads on one end of one rod, then a division in the frame, then two beads on the other end of the rod. There are two 5's in ten that make a positive count, and you can keep track of the carrying by means of the other two. But the more common form of abacus is what is known as the Greek abacus, which is still used almost universally in

Russia, and in many countries of Eastern Europe. It has nine beads on one rod, then a division, then one bead.

It would be rather difficult for you and me to sit down with a lot of pebbles and try to compute with them, but that is because we didn't learn to do it that way. Perhaps if we had spent as much time learning to compute with pebbles as we have learning to play whist, we could do it with surprising rapidity. Orientals do those things very rapidly; in fact, the Japanese have a sort of mathematics with many short cuts that are worth studying, because they show us short cuts that we never thought of. They have the same number of fingers and consequently the same decimal system that we have. Naturally we can profit by some of their mathematical discoveries.

The First Counting Machine

The first counting machine that we have in written history comes through a man named Gerbert. Gerbert was a shepherd boy. A monk noticed that he was very ingenious, very bright. He made an instrument for playing music by peeling the bark off limbs of trees, and fitting it with reeds; then he ran water through a pipe to force air down and vibrate the reeds. So the monk educated him. He knew that at that time, which was about 900 A. D., practically all the knowledge and science of the world was possessed by the Moors. They occupied southern Spain, as well as north Africa.

The Moors had two great universities, one at Cordova and the other at Seville, but no Christian could enter them, so Gerbert associated for some years with Moors, lived their life and adopted their customs, and learned the Mohammedan religion. Then he disappeared from the monks, those who had known him before, and in Moorish garb applied at

one of these universities to be taken in. As he seemed to be a good Mohammedan, they took him in and he went through that university and then he went to the other. After he had graduated from both, he came back into Christian Europe.

When Gerbert came back he brought with him what we call the Arabic numerals. They are what we use. But they were then very different in form from the Arabic numerals as we write them today, because we have changed them. They originated in northern India. The Arabians used nine significant digits and the ciphers.

Gerbert came back in the year 960, I think it was, or within three or four years of that. Printing was unknown. Consequently, the knowledge that he brought back to Europe did not spread, and it wasn't until several hundred years afterwards, until the invention of printing, that the Arabic numerals came into general use. When he came back he brought with him a plan for a calculating machine that the Moors had been working at, but had never succeeded in making work. He spent many years of his life trying to make it work. He thought he could, but he could not. He could not get accurate results at all. Otherwise he was very successful; afterwards he was Pope of the Roman Catholic Church—Sylvester II.

Early Calculating Machines

But another Spaniard took up the idea and made a calculating machine. His name was Magnus. As far as we know his machine worked. History says it did, but having seen some twenty famous old calculating machines in Europe made three or four hundred years ago, I have my doubts about its accuracy. It was formed of brass, in the shape of a human head, and the figures showed where the teeth came.

Another man, at the same time, named Bacon, made one also of the same character. I say at the same time. Magnus made his shortly after the year 1000 A. D., and Bacon made his perhaps ten, fifteen, or twenty years later. It is not known exactly. What became of the machine of Bacon is not known, but the one that Magnus made was smashed with a club. The other priests—they were both priests of the Catholic Church—thought it was something superhuman. He tried to make out that it was, and concealed the fact that it was a piece of calculating mechanism. So they smashed that one up.

Those were undoubtedly complicated pieces of machinery, but they accomplished no more than the little twenty-five-cent adding machines that we now see, consisting of three or four little discs in a row, where you insert a stylus and turn the wheels around. This modern simplicity is due to the mechanic arts having developed more fully.

In those days the necessity for calculating machines was realized much more than it is now. If you write down a problem, like 4,625 multiplied by 360, in what are called Roman numerals—the numerals that we use on the dial of a clock—you will see it would be very difficult to multiply. For that reason you will see that addition was almost as difficult, because there were no individual columns—units, tens, etc.—the digits in each falling one beneath the other. So there were only a very few of the people who could multiply, or add or divide, or do anything in mathematics. Those that could were considered something strange, like an astrologer. That condition continued until the middle of the seventeenth century.

They had adopted the Arabic numerals, I think, quite generally, about the fifteenth century, but it was easily some hundreds of years after that before arithmetic, as we teach

it to the children in school, became generally spread among the people. Even for hundreds of years afterwards the people did not seem to acquire that facility of mental calculation that we practise today. Consequently, efforts to make mechanical calculators were very great and very long continued. A mere list of the noted scientific men that devoted many years to the subject would contain hundreds of names.

Pascal's Mechanical Calculator

But among all that number certain ones made a little step forward here and there; they made some progress. There were many ambitious efforts to make what we would now call a highly organized mechanical calculator. None of those succeeded. The most famous was by Pascal in 1642. He is credited with being the first to make a mechanical calculator. But I do not think he fully deserved it. He didn't make one that would calculate accurately, even if you handled it with the greatest care and took hold of the wheels and cogs after taking the top off the machine, trying to help them along. I have tried them myself on several of his machines which are preserved, and making due allowance for age they never could have been in any sense accurate mechanical calculators. Furthermore, they were very large; probably eighteen inches long, ten inches wide and six or eight inches high. They would have accomplished nothing more, even if they had worked, than these little things you stick in your vest pocket, with four dials which are operated with a stylus. His machine was operated exactly the same. But its great bulk, the largeness of the machine, was occasioned by the very complicated carrying mechanism, to transmit tens from one order to the next, units to tens, and tens to hundreds, etc. But, having been the greatest scientist of his time, and having a great many friends, and being a Frenchman—(the French recorded the efforts of the dif-

ferent attempted inventions in calculators more perfectly than any other nation)—he is given a great deal of credit in that direction.

Sir Samuel Moreland, in England in 1663, made a mechanical calculator which was practically in all respects the same little disk machine of today, compact and simple. He was a famous scientist also, but his machine didn't come into very general use. Probably there were a few hundred used. Some are still in existence. That was about two hundred and fifty years ago.

Pascal was undoubtedly a great scientist in many different ways. He did many things for the human race, and one of those for which he is most celebrated is the invention of the omnibus, called the twenty-centimes omnibus. That would be about four cents fare, and his omnibus was the first thing of the kind known. He is very famous for that, much more so than for the great many books he wrote on science. The foundation of several branches of science is found in his books.

Pascal started at his calculating machine very young. He was only about eighteen. His father was what we call a customs officer and the boy was often made to compute. It was very laborious, and so he conceived the idea of making this machine. It is said that he had never heard of anything of the kind before, but there are records of many attempts before him.

The Work of Leibnitz

About that time, or a little later, there was a great scientist in Germany, named Leibnitz. He was probably a greater man than Pascal. He is said to have been the inventor of the differential calculus, on which nearly all the higher mathematics, as practised in engineering, is based.

It is a question, however, whether he really was the first to invent the differential calculus. The English say Napier did it. Napier was also a great scientist and wrote books, so what he did was preserved.

Leibnitz never wrote many books, but wrote a great many letters. Those letters are so important that you can go to our libraries today and find photographs of hundreds of letters written by Leibnitz. Many of the fundamental principles of our present-day science are found for the first time in those letters. He is said by some recent scientists to have possessed the greatest brain the world has ever known. He was honored and decorated and received by the Czar of Russia and the Emperors of France and Austria, and by many of the German kings, but he was not satisfied. He was jealous of Pascal, so he went to work to make a calculating machine, because in that day Pascal was noted more for his calculating machine than for other things much more valuable and wonderful.

Leibnitz had some money—250,000 francs, they say. He spent all he had and his calculating machines didn't work. He made two or three. He employed watchmakers to do the work, and he blames their failure to the watchmakers, the same as Pascal does. Both blame it to the mechanics that their machines were not entirely satisfactory.

It is said that Leibnitz worked twelve years on his machine. He wasted all the money he had, and dropped out of sight. There was only one man that went to the grave with his remains when he was buried, in absolute poverty. A few years before he had been noted as the greatest scientist in Europe.

It was claimed by some that another man in France, Grillet by name, who knew of Pascal's efforts, tried to make a calculating machine, and that he came much nearer to

success in making an accurate machine than did Pascal. The machine was not used, but was exhibited for a fee, and then all of a sudden it dropped out of sight and nobody knew what became of it. So some claim that Leibnitz didn't generate any machine, or rather any mechanism for his machine, out of his own head, but that he procured this machine in France and took the inside out of it and put it in another case.

When I was in Paris a few years ago, I saw the case Leibnitz is supposed to have taken the mechanism out of. I examined it very carefully, and I also examined another machine very much like it, that has the insides still in it. When I was at the Royal Library, Hanover, Germany, I had Leibnitz's machine open and examined that very carefully, and I am sure that there is no possibility that Leibnitz could have used any of the mechanism out of the machine made in France. The two machines are entirely different in organization, starting from different conceptions, and, I was going to say, arriving at different results; but they all ended in failures, which is true of all attempted highly-organized calculating machines up to the year of 1820.

The First Successful Machine

Charles Xavier Thomas, a director of an insurance company in France, made a calculating machine in 1820 and it worked. Without question it was the first one that ever did work practically and usefully. When I say a calculating machine I mean a highly-organized machine, because there had been devices for calculating, like the abacus, before that, which worked; simple devices that were practical and useful, some of them used to a very large extent, but they were not devices that we would use. They were less automatic.

One of these simple devices, which is quite as famous as

the machine of Pascal, was invented by Napier, of Scotland, the inventor of the differential calculus. Napier wrote the multiplication table on some little rods. He didn't write it as we find it in our textbooks in school, but he wrote it on square rods, in such a manner that the tens figure of each product in the multiplication would fall in a triangle, opposing another triangle in the same square containing the units figure of the product corresponding. He used rods about the size of a pencil, with parts of the multiplication table written on them, only there were four sides. For instance, the products of 6 written on one side, those of 7 on another side, and so on. He would select rods corresponding to the multiplication and lay them alongside of one another, ascertain the first sub-product by a simple addition, write it down, then get the next sub-product by the same means, and so on, finally adding all the sub-products together. If he had to multiply 243 by 46 he would do it by three mental additions.

Those rods (Napier's rods) were used very largely, not only in England, but all over the Continent. They were considered a great thing, and people not understanding that it was simply the multiplication table written on strips, thought there was something mystic about it, and he was very much honored for the invention. No doubt he originated it out of his own mind, but the same thing was known to the Arabs many years before that; in fact, they practise something like that today, but have it arranged a little differently.

In the meantime, between Leibnitz and Thomas, there were several men who made machines which are still in existence. There was a man named Poleni in Venice, who made a machine in 1709, but that machine is not in existence. It was a very near approach to an accurate calculator, but not reliable enough to be used to any extent. There are

two machines in the museum at Munich, Germany, which are said to be copies of it, made at the same time, and they are wonderful pieces of mechanism. They are beautiful to look at, very far superior to most of the calculating machines of early times.

The Odhner Type of Machine

In 1775 Earl Stanhope, in England, made two machines. Some say he copied Pascal, but he didn't. His are very different. One of them, if it had worked accurately, would have been the prototype of that class of machine known as the Odhner type. Odhner lived in Russia. Some say he was a Pole, but I believe he was a Scandinavian. He made a successful machine about 1876. There is a great family of machines made in Europe at present, known as the Odhner type; probably twenty factories making such machines. The Brunsviga is one of them. Odhner manufactures them himself in Russia, but he is not so successful commercially as are the French and German manufacturers of that type of machine.

But a hundred years earlier—1775—Lord Stanhope had in his machine the heart of the Odhner machine. Each kind of machine—I do not care whether it be an automobile or a calculating machine—has some fundamental feature, some heart, some key to it, which represents the invention, which once thought of and produced successfully, the rest is easy. That feature of the Odhner machine is found in the machine of Earl Stanhope for the first time. But it is not accurate and never was. It is very fragile. They wouldn't let me operate it in the museum where it is preserved in London, but I examined it very closely. No doubt it could be operated if handled very delicately and would get results.

Another machine made by Earl Stanhope about the year 1777, contained the heart of what is known as the Thomas type of machine. That machine contained a series of toothed wheels, having wide faces bearing ten very long teeth; the first one, reaching clear across the face, representing 9, the next tooth being one-ninth shorter, the next one-eighth shorter, and so on. If you want to add 9, you shove the toothed wheel along so that nine teeth will engage; if 8, you shove it along so that eight will engage. That is in the second Stanhope machine, and it is the general principle of the Thomas machine. In the Odhner type they get the variable number of engaging teeth by having a wheel with movable teeth in it so they can slide in and out. As they turn a lever more or fewer teeth slide out.

Those two Stanhope machines are probably, barring Leibnitz's, the first attempts to make any machine on either the Thomas or Odhner principle, although there are some very old machines in Germany that contain the Odhner principle, and I am trying to find out about them.

Perhaps, however, I am not quite fair to Leibnitz. Leibnitz anticipated the Thomas type of machine in so far as he had the cylinders with longer and shorter teeth, etc., but his organization was so entirely different from the Thomas organization or anything that has ever been brought to a successful conclusion that I could hardly say that he anticipated Thomas in the same sense that Earl Stanhope did.

"The Fault of the Mechanic"

Earl Stanhope was another fellow who had his machines made by watchmakers, and he also blames the lack of success to the men who made the machines. I guess he is right. There is no doubt it was the fault of the mechanic. The whole thing rests with the mechanic. He deserves all

credit and all blame. Anybody, with a little bit of study, can think up a calculating machine; it is no trouble at all. There are any number of ways to go about it, and devise something in the air or on paper; but it is a very difficult proposition to make one that will be simple and produce accurate results in use. There is hardly a week that I don't get a letter from some man who has invented a calculating machine far superior to anything now on the market, and he wants me to give him the money to patent it, and if I don't, he says he will take all the calculating-machine business away from all the rest of us.

It looks simple. When I first thought of making a calculating machine, I was working in a machine shop. I was running a planer. A planer has a tool that runs back and forth across one or more notches according to how you adjust it. I said, "Why can't that be used for counting?"

I thought about it all night, and pretty soon I said, "I will make such a machine."

I had a friend who was an electrical engineer, and I told him what I was going to do, and said: "In ninety days every office in the United States will be doing its calculating by machinery."

So I went to the grocery and bought a macaroni box to make the frame of. I went to the butcher and bought skewers to make the keys of, and to the hardware store and bought staples, and to the bookstore and bought rubber bands to use for springs. I went to work to make a calculating machine, expecting to have thousands in use in ninety days. I began on Thanksgiving Day, because that was a holiday, and worked that day, and Christmas and New Year's, but I didn't get it done in three days. It was a long time before I got it done.

Modern European Machines

To go back to the history of calculating machines:

Another man made a wonderful machine in 1777, containing the Odhner principle which I saw in Germany. He made another in 1809 which did not contain the Odhner principle.

The Thomas machine is still being manufactured in the same place, in Colmar, France, in which the first one was made, three generations ago. It worked. It was useful and a great many were used. It didn't get out of France until about forty years ago, when the insurance people took up the subject, and particularly through the efforts of a college for actuaries in Scotland, the science of using the Thomas machine was written up and advanced. There is a lot to know about mechanical arithmetic.

Then a man in England began manufacturing a copy of the Thomas machine, a man named Tait, and he is still manufacturing it in London. He made a splendid machine. It is the best constructed machine made in Europe. He sold it for $450, and a good many were used in this country twenty-five years ago. It is the most accurate calculating machine and the only durable calculating machine ever made in Europe.

But Tait had no commercial ability whatever. The chief accountant of the Great Western Railway in England called at my hotel in London one day, a few years ago, and I asked him about Tait. He said Tait had then two or three mechanics working in London; yet he was then making, and has made for twenty-five years, the only nearly accurate and durable calculating machine made in Europe, in the sense that we Americans consider a calculating machine accurate and durable. I don't mean like the old machines that wouldn't be accurate no matter how delicately you use them;

but the Tait is a very accurate machine. Yet I have in my possession a pamphlet issued about twenty years ago, when Tait was doing considerable business, in which he starts out by telling that you must, every time before you start to use your machine, test it and then adjust the springs with some little screws until it computes accurately; and then he goes on and cautions three or four times, "Don't run it too fast." Nevertheless, the Tait machine was far and away above any European machine made today or heretofore, regardless of the fact that many calculating machines are being used in Europe.

The Brunsviga Machine

Nearly every large office in Europe uses a number of the Brunsviga machines, but every one of them will overthrow the numeral wheels and give a wrong answer if operated rapidly. The recent catalogues of the Brunsviga machine say they have overcome that difficulty. We have seen that claim time and again for—I guess—fifteen years, and we will see it until they start from a different standpoint to build a machine on a different principle.

The Brunsviga people are very energetic. They put money into pushing their business, and they sell a great many machines all over Europe. Even the French, before the Great War, bought this German machine. If you were a German on the streets of Paris before the war, and called a cabman, most likely he wouldn't take you, although it was against the law to refuse. Yet they bought the machines made in Germany, despite their having eight or ten calculating-machine factories in France.

There is no question but what the first machine that was accurate enough to be of any practical value was the Thomas machine of 1820. The Odhner machine was the next. And

the Brunsviga machine was originally made under patents granted in Germany, which, of course, have expired.

The Babbage Calculator

Perhaps the most famous machine in English literature is the Babbage machine, and it is always spoken of as a calculator. It was a calculating machine in one sense. But it was not a machine that would do multiplication, or division, or addition. The theory was to make tables by use of the Babbage machine and then use the tables. To compute mentally and print accurate tables is very difficult. Babbage was a noted English scientist. You can find his books in all the large city libraries, many large volumes pertaining to different scientific topics.

In the case of the Babbage machine the idea was to construct a machine to grind out a single table, and then after making and putting into the machine many new pieces of mechanism, grind out another table, and so on;—practically making a new machine for each table. It was quite a large machine. Babbage never finished it, but about 1833 he made part of it. The part he made was about three feet high. It was beautifully made, but it was not wholly reliable. He ran out of money, and the Parliament of England appropriated for his use seventeen thousand pounds sterling. He used that up and then for some time did not do anything more to the machine until Queen Victoria offered to assist him; but then, instead of completing the first one, he started in to make quite a different machine, called an "analytical engine." It was for a different purpose altogether. It was intended to develop algebraic expressions. Then he died. So he never completed either one, but the one which he partly made, called a "difference engine," is now on exhibition in England, and is very famous.

One British encyclopedia devotes many pages to that machine, and Babbage wrote about it as though he had actually made a machine. He never made it, and could not if he had lived a thousand years. The object he was trying to attain was all right. He was aiming at the right thing, but he could not produce it.

A Successful Swedish Machine

Just about that time a man named Scheutz, in Stockholm, conceived the idea of making a machine for the same purpose. He was publishing a technical journal for civil and mechanical engineers, but he did not produce the machine alone. His son, before he was twenty, while in school, or just about the time he came out of school, took it up and between the father and son they constructed a machine. They were assisted by one appropriation of $2,700 by the Swedish Government. That machine worked. It was begun in 1837 or before. Just when it was completed is not certain. But it was exhibited in England in 1855. It was being used in one of the Government offices in London in 1862. It was employed to compute a mortuary table—a table of the probabilities of the length of human life. They had very few data to work on, but they had the life statistics of several cities in England, and from them they made the table, which was published in book form and used by insurance companies for many years. It was the first mortuary table ever made. It was accurate.

One thing that both Babbage and Scheutz appreciated was that all tables computed mentally are more or less inaccurate, due to errors in transcribing and typesetting the figures. So they were going to overcome that difficulty by having a machine make the type forms they printed the tables from. Babbage never completed this machine, but

Scheutz made his successfully. To make the type to print them from, he had a strip of lead about three inches wide, into which the answers were impressed as fast as computed, something like a listing machine prints its answers on paper. The answer mechanism used by Scheutz was the same stepped device used by Hiett. The machine was turned with a crank, as we turn a cider mill, and as the machinery ran along it computed and pressed the figures into lead. Then they made stereotypes from the lead plates to print from, so that they got right onto the paper the very figures made by the machine. There was no chance for a mistake in transcribing.

They found it was very difficult to keep the Scheutz machine in running order. The British Government appropriated some money to build another on the same plan, only larger,—that is, to take in more columns,—and was going to have it built in a British shop, and then, of course, according to British ideas, it would work accurately. The people in those Islands think it must be perfect if made in Britain, and if it isn't made there it isn't perfect.

They built this machine in the great engineering works of Bryan, Donkin & Co., in England, and it is supposed to have been very much better than the one built by Scheutz, but I have not seen it. It was said to have been in the South Kensington Museum at one time, but I could not find it or any record of anybody having seen it for years.

The first Scheutz machine is now at the Dudley Observatory, Albany, New York, and while the workmanship is not that finely finished instrument-maker's work seen in the portion of the Babbage machine that was constructed, it is "all business." You can see it is a machine in which the man kept the object he wanted to accomplish in mind, and didn't want to make any mirrors for the ladies to look into,

so his money held out till he produced a thing that could be used. It was bought by Mr. Rathbone, an American, and presented to the Dudley Observatory some years ago. They tried to use it, and I believe did use it somewhat in the Dudley Observatory, but they are not using it any more, and when I saw it, they kept it in a room full of old rubbish. If that machine was in Europe, they would build a special building to keep it in. France would, anyway, and so would Germany.

Historic Machines in France

In Paris they invited me to come to the National Conservatory of Arts and Meters, on a day when it was closed to the public, and gave me a man with a screw-driver to open machines for me to examine. I spent several hours there. They have many historic old calculating machines there, and I brought away the catalogue and a volume on calculating machines, written by Professor Maurice d'Ocagne. Naturally, I paid most attention to the machines the history of which I was already familiar with. But I hope to be able to determine whether there is any older machine than the Pascal. In the literature the Pascal is the oldest—but I think there are some machines that date back nearly to the year 1000.

There is one interesting Chinese machine there. We have always thought of Chinese calculators as being the abacus and nothing else, because that is what they usually use. But in Paris there is a Chinese machine that has wheels and springs and is operated with a stylus. This machine is about four inches deep and six inches wide, and it has a lot of slots in the top of it, shaped like a shepherd's crook. It is operated something like the Goldman machine, which is well known in America, only instead of having carrying mechanism inside, the slot for the stylus ends in a turn so

as to carry the stylus around and back. It has a series of black and a series of white numerals showing through each slot. If the number to be added is found among the black numerals, you go in one direction; if found among the white, go in another direction. There was a very simple machine on something like that principle—really a very wonderful principle—advertised from Iowa by Locke up to quite recently.

Thomas was French and Stanhope was English. Leibnitz was German. Moreland was English and Pascal was French. There are a great many French inventors in the books, hundreds of them, but no one until Thomas ever made any highly-organized machines that would work accurately until very recent years, and none, except those who directly copied Thomas and Odhner and maybe Grant, made anything that would be considered useful in our day, until key-operated machines came in.

Bollee's Machine a New Type

In the year 1889 a Frenchman named Bollee made a machine of an entirely new type on entirely new principles. He made it when he was eighteen years old, and they say he never had heard of a calculating machine before. That was another case where the boy's father was a customs officer and he had to do computing. (By the way, Pascal was only twenty when he made his first machine; and Scheutz, the real inventor, Scheutz the son, was only about twenty when he made his machine. Several of the early inventors of calculating machines were under twenty-two or twenty-three.) This machine made by Bollee was for multiplication and division. It would be entirely impracticable for addition, and it wasn't as useful for dividing as the Thomas or the Odhner. For multiplication and division it

was very good, but for division you had to estimate what your quotient figure was every time before operating the machine, which you don't have to do with the Thomas or Odhner. Nevertheless it is often used for division, and is very good for multiplication. You probably sometimes see that machine now, or one containing the same principle, in what is called the Millionaire. The Millionaire is manufactured under the patents of E. Steiger of Germany. It is manufactured in Switzerland. The principle of the Bollee machine was another case of the multiplication table put into material form.

Napier put the multiplication table on bone rods by engraving on them the figures representing the multiplication table. Bollee didn't do that. Bollee took a plate of metal and stood on it a series of pins of graduated lengths. One pin would be 1 unit high, the next 2 units high, the last pin of the series 9 units high. This represented the first nine steps of the multiplication table, once one, once two, once three, etc. The next series of pins was first 2 units high, the next 4 units high, and so on, and stood for 2×1, 2×2, and so on.

He arranged these plates to slide back and forth in the machine in such manner that when the operator moved the knobs attached to the plates carrying the graduated pins so as to set up on the machine any certain number,—for instance, as one would set the multiplicand on the Thomas or Brunsviga,—and then moved a crank along an index, leaving it at any particular figure,—for instance, 7,—then by moving a second crank the machine would instantly indicate seven times the multiplicand originally set up. By an operation of this kind for each figure of the multiplier any problem in multiplication could be performed.

A small number of the Bollee machines were made and

used, but in recent years he has gone into the automobile business and I guess he will not make another, because money is easier made in automobiles than in calculators. It was a fine machine, with much mechanism in it. It was used for making tables as well.

The Steiger machine, usually known as the Millionaire, instead of using pins, employs notches in disks, the disks turning around. It is the same principle, except that disks with notches supplant the rows of pins.

A man named Saunders in New Jersey about ten years ago carried the Bollee principle still farther, using the Steiger form. On the Millionaire and Bollee you have to set two or three things and move a crank for each figure of one factor, but Saunders made a machine in which you simply set up on one series of indices for the multiplicand, and another for all the digits of the multiplier, and then by moving the second crank once the answer is at once displayed, instead of having to move both cranks for each digit of the multiplier.

Machines of Recent Invention

Now, to come down to more immediate times, Pottin—I believe he was a Frenchman—made the first attempt to construct a key-operated machine to add and print. A man named Baldwin in St. Louis, in 1872, made a calculating machine that added and printed, but it was not key-operated. He used the Odhner principle in his calculating mechanism. He made a number of machines. In the literature of the subject he is quite famous as a maker of calculators, although he never made but four or five. One of his models is in the Patent Office at Washington. It is a beautiful piece of mechanism; but it would last about thirty minutes if you tried to use it in the rapid and rough way

calculating machines are used in this country. It worked if you handled it with great care. That machine would add and print a list of numbers on a tape of paper.

There was a machine made about the same time by a man in Germany named Sellings, which did the same thing. It is in the museum in Munich. Also a later machine by him, which does not print. I believe it was all right as a multiplying machine, but as a listing machine I don't think it amounted to much. The underlying principle of the Sellings machine was quite original. There are two Sellings machines in the museum at Munich, each very different from the other. The first was somewhat crude and fragile. The second one was more substantial and looks as though it would stand some practical use.

Of course, it could be said that the Scheutz machine added and printed, because you could read the type that it made to print by. It could be said that that was a listing machine, but it was a mighty slow one. Some of those early machines were operated by power. I believe the second Scheutz machine was. Prof. d'Ocagne in his book on mechanical calculators mentions several early machines operated by power, one by an electric motor.

Pottin in 1883 took out a patent in France, and a patent in England. He registered in each case from Paris, France. He has taken out four patents in this country, but I have never been able to find out for sure what Pottin's native country was, and I wouldn't be surprised to find that it was America, because his first patent was taken out from Philadelphia.

Pottin actually made a machine, but I cannot find what became of it. Prof. d'Ocagne, who has written several volumes on the history of mechanical calculators, never heard of Pottin until I told him about him. Once I met a patent

lawyer who claimed to have gone to Europe and investigated Pottin's machine, and said he found that one was made and that it worked; but it seems strange to me that, if it did work, they would not know something about it in France, where they get so excited over our Comptograph or Comptometer.

[Editor's Note.— With the modesty of a successful inventor, Mr. Felt concludes his lecture without mentioning the marvelous results of his own efforts to give the business world a practical counting-machine of convenient size, absolute accuracy, great durability, and moderate cost. But his machines speak for themselves in thousands of busy offices, not only in the United States, but throughout the civilized world.]

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